

**ON THE ECOLOGY AND BEHAVIOR OF *CERAUTOLA CROWLEYI*  
(SHARPE, 1890), *CERAUTOLA CERAUNIA* (HEWITSON, 1873)  
AND *CERAUTOLA MIRANDA* (STAUDINGER, 1889)  
WITH DESCRIPTIONS OF EARLY STAGES  
(LEPIDOPTERA: LYCAENIDAE, EPITOLINI)**

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**Abstract** – Very little is known about the ecology and behavior of the strictly African *Cerautola* species (Lycaenidae: Epitolini). Nearly nothing has been published about their early stages until now. This paper summarizes the results of a study of three species of the genus from Ghana, including descriptions of their myrmecophilous relationship with *Crematogaster* ant hosts. Detailed descriptions of the early stages are presented here for the first time.

**Key words:** Ecology, behavior, early stages, myrmecophily, *Cerautola crowleyi*, *C. ceraunia*, *C. miranda*, Lepidoptera: Lycaenidae, Epitolini. Formicidae, *Crematogaster*.

The genus *Cerautola* Libert (1999) was introduced in the course of a revision of the Epitolini (Lycaenidae: Lipteninae) to describe large *Epitola* species. It is a strictly sub-Saharan genus restricted to the equatorial and western humid forest zones in Africa. The genus contains only a handful of species, characterized by a falcate forewing, with elongate apex in some cases, intensive iridescent blue or deep blue color on the males' upperside, and strong sexual dimorphism. The females are darker with reduced blue, even being completely brown as in the cases of *Cerautola legeri* Libert, 1999 and *C. miranda* (Staudinger, 1889). Very little is known about the ecology of the *Cerautola* species, and nearly nothing is published about the early stages in Larsen (2005) and Williams (2008), although line drawings of few Epitolini species appeared in Farquharson (1921) including *C. ceraunia* (Hewitson) and the Central African *C. hewitsoni* (Mabille). The authors present new information on the ecology and adult behavior of all three *Cerautola* occurring in Ghana and report the finding and rearing of larvae of the species. The descriptions of the larvae and pupae are also given in this paper. All three species have an apparent myrmecophilous relationship with arboreal *Crematogaster* Lund ants.

#### THE STUDIED AREAS AND HABITATS

Most of the investigation on *C. crowleyi* and *C. miranda* took place in Aburi Botanical Gardens (5°51'10.68"N, 0°10'28.49"W), Akwapim Scarp, Eastern Region, Ghana, West Africa. The Gardens were established and operated as a hospital and sanatorium for British soldiers and officers in the second half of the nineteenth century (UNEP-WCMC 2002). The sanatorium had a beautiful park with many ancient trees and well-designed flower gardens, which later became the core area of the Gardens. Not surprisingly, the area was popular with early entomological collectors and many species described during the 1870-1890 period by workers like Plötz, Möschler, Hewitson, and Mabille have Aburi as the type locality (listed in Larsen, 2006).

The Gardens can be divided into two major parts. The smaller area is mostly original parkland of the sanatorium, traditional cocoa farm demonstration plots and recreational areas dating back 100 years, the second is used for displaying a medicinal plant (tree) collection and for forest demonstration, and covers approximately two-thirds of the Gardens. While the first is mostly characterized by old, sometimes truly giant trees, and open areas with regularly mown grass and flowery bushes, the second is mainly degraded forest and secondary growth. The total area is approximately 200 hectares and was once part of the extensive rainforest that stretched continuously from the southern slopes of the Akwapim Scarp to the plateau of Nkawkaw in the north. Part of this forest area was still in good condition in the late 1970s, and the special upland climate allowed the area to have a number of very rare West-African endemic species such as *Eresiomera jacksoni* Stempffer and *Micropentila mamfe* Larsen, but the forest has largely disappeared. The Gardens remain an important refuge for many forest species, including the recently described *Cephetola collinsi* Libert & Larsen and *Mylothris aburi* Collins & Larsen (Larsen 2005).

Other observations were made near Kakum Forest (5°21'26,28"N, 1°22'16,61"W), a large lowland rainforest area in the Central Region just outside the national park, where some parkland and remaining forest is being developed for ecotourism, and in Bobiri Forest Reserve and Butterfly Sanctuary (6° 41'12,68" N, 1°20'39,80"W), a popular tourist destination, situated right in the transition zone of moist semi-deciduous and dry semi-deciduous rainforests. The latter two areas are characterized by presence of closed forest and secondary growth that is interspersed with more open parkland with large trees.

We also present several observations on the adult behavior of *C. crowleyi*, *C. ceraunia* and *C. miranda* from Likpe Mate, Biakpa Avatime and Amedzofe in the Togo Mountains of the Volta Region.

## THE ECOLOGY AND BEHAVIOR OF *CERAUTOLA* IN GHANA

Morphological descriptions of the imagos of *C. crowleyi*, *C. ceraunia* and *C. miranda*, including an identification key and color images, are given in Libert (1999) and Larsen (2005). All are widely distributed forest species, concentrated in the moist evergreen forests in Ghana (Larsen 2005, Larsen 2006). *C. crowleyi* has been reported from Guinea-Bissau, Guinea, Sierra Leone, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Congo, Central African Republic, Gabon, Democratic Republic of Congo, Angola, Uganda, Tanzania and Zambia, while *C. ceraunia* is known from Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria (south), Cameroon, Congo, Gabon, Angola, Central African Republic, Democratic Republic of Congo, Uganda and north-west Tanzania. *C. miranda* is recorded from Guinea, Sierra Leone, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Congo, Central African Republic, Gabon, Democratic Republic of Congo, Angola, Uganda, Kenya, Tanzania and Zambia (Libert 1999, Larsen 2005, Williams 2008).

Only *C. ceraunia* is relatively common throughout the forest belt of Ghana, but all three species have regularly been found in the parkland at Aburi. *C. crowleyi* and *C. miranda* were mostly recorded from forest edges or more open secondary forests and in the savannah-forest mosaic of the Togo Mountains in the Volta Region. Records from closed primary rainforests are few; until recently neither had been recorded from the major national parks of Bia and Ankasa, nor from the well-explored Atewa Range Forest Reserve (Kibi).

Little information about the ecology and behavior of the *Cerautola* is available in the comprehensive literature of African butterflies (see above). Our impression is that all three species have the following essential requirements: 1) ant-trees (that are best described as usually old trees which host the carton-like nest of ants belonging to different species of the genus *Crematogaster*; 2) adjacent open spaces of some size, including hilltops, to act as display-grounds for males; and 3) the first two should be situated inside or near primary forest or older secondary growth within the tropical forest zone to ensure that the right climatic conditions are available for the survival of both the butterflies and the *Crematogaster* ants.

### Adult behavior

The flight of all species is very fast and erratic when disturbed. Males have been observed displaying, mostly in open areas around trees containing ant colonies, or on treetops normally several meters above the ground. Hilltopping behavior was observed for *C. crowleyi* and *C. miranda* in mountainous areas in the Volta Region, even on hilltops, where only few trees were available. The display flight of *C. ceraunia* occurred between 09.00 and 10.00, while *C. miranda* males displayed between 11.00 and 12.00, and *C. crowleyi* was observed displaying between 12.30 and 14.00. Such time-specific displays and/or hilltopping is known among the smaller Epitolini as well (Libert 1993, Larsen 2005). The flight and flight-pattern is very characteristic; a fast and powerful lift is followed by a gliding

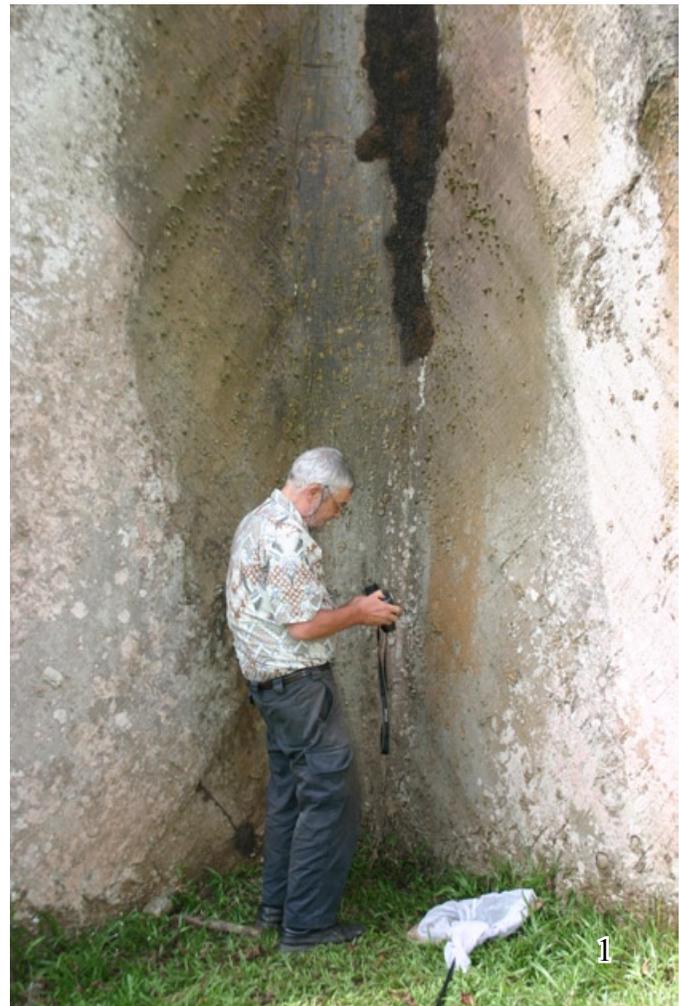


Fig. 1. Torben Larsen next to a large ant nest, Aburi Botanical Gardens, Ghana.

swoop after a narrow-angled turn, in a square- or polygon-shaped “parade-ground”. Males often engage in intra- and interspecific fights (*C. ceraunia* males were observed investigating shiny blue objects even at ground level). They settle on dry twigs or creepers when basking or displaying their iridescent blue color to the approaching females. Apart from the display flight, they are seen on the wing only rarely when disturbed from their resting places, sometimes low down on dry palm leaves, twigs, creepers or tendrils close to ant trees. Females are normally active in the early afternoon from 13.00-15.30 when they investigate tree trunks for presence of *Crematogaster* ants and lay their eggs. *C. miranda* was frequently seen flying spirally around trees up and down; once it found a “good ant-tree,” it approached the nest and laid eggs singly 20-30 cm below the nest between ant trails. The process was repeated 3-5 times before the female left the tree. This behavior is probably the same when the ant nest is found high up in the canopy level, but the egg-laying was always observed at the lower, sometimes ground level. All (approximately fifty) larvae were found no higher than 2-3 m above ground. The only exception is *C. ceraunia*, where large clusters of larvae were seen high up near ant nests from afar (the small clusters of resting larvae of *C. crowleyi* and *C. miranda* are difficult to find). The egg-laying strategy of *C. crowleyi* may be similar, while *C. ceraunia* females differ from the other two by



laying eggs in large clusters (up to 60-80 eggs) while spending more time on the tree-trunks. Imagos of all species were found to emerge at 10.30-12.00 in the morning: they usually did not fly on their first day after eclosion from pupa.

#### Rearing the larvae

On 3 November 2006 a cluster of larvae was found, resting on the bark of one giant Silk Cotton Tree (*Ceiba pentandra*), 20-30 cm below and to the sides of a large carton nest of *Crematogaster* ants at the height of 2.4-4.0 meters in the Aburi Botanical Gardens. The larvae superficially had a moth-like appearance like many Lymantriidae, but were surrounded by *Crematogaster* ants, which indicated that they belonged to the Epitolini tribe of Lipteninae (Lycaenidae) as described by Farquharson (1921) and Williams (2008). They also resembled

Fig. 2-5. *Cerautola crowleyi* larva, pupae and adult male.

*Iridana* larvae found by Larsen in Aburi previously. At least 20-30 larvae in all stages were present in separate clusters of 4-12 larvae, which were passive during daytime. Little interaction with ants was observed: solitary ants regularly approached the larvae leaving them immediately after the first contact (Fig. 2). When the larvae were disturbed or collected, the ants did not react, indicating that no ant alarm pheromone mimic was released. Callaghan (1992) recorded that when he was collecting a larva of *Aethiopana honorius* Fabricius, the ants became agitated and attacked it, but this unusual behavior was obviously provoked by him. No larvae were ever seen approaching the actual ant nest and the authors did not attempt to open and seek for larvae in the nest. The larvae did not spin silk webs as was observed by Farquharson (1921) and Larsen (2005) in two species of *Iridana*.

Closer study revealed that two different butterfly species appeared to be present in the various clusters, in all larval stages from L1 to L5. Though the nature of the relationship with the ants was unknown, the authors attempted to rear the species without keeping *Crematogaster* ants in their environment. Four last-stage larvae of each species were placed in plastic food-boxes provided with pieces of tree bark covered by lichens, moss and algae as food source. The larvae accepted the food; they literally “grazed” lichen from the bark, mostly during the night, and after few days most of them successfully pupated



Fig. 6-8. Larva, pupa, and adult of *Cerautola miranda*, Aburi Botanical Gardens, Ghana.

on the tree bark. The shapes of the pupae confirmed that the larvae belonged to two different species, though from the structure and the behavior of the larvae it was suspected that they belonged to the same genus. The species were first thought to be *Hewitsonia* spp. because the commonest species of all *Epitolini* present was *Hewitsonia inexpectata* Bouyer, 1997, though *Hewitsonia boisduvalii* (Hewitson, 1869) was also observed during the survey. The size of the pupae was sufficient to be *Hewitsonia*, but *Cerautola* was also among the potential genera. The image of larva of *A. honorius*, given in Callaghan (1992), also resembled the ones found in the Gardens. Ten days after pupation the first specimen successfully hatched, resulting in a male *C. miranda* on the 18<sup>th</sup> of November 2006 (Fig. 6). Ten hours before hatching, the blue color and the shape of the wing was already recognizable through the pupal case

(it is worth noting that Farquharson (1921) bred larvae of *C. miranda* but he did not give further account on the behavior and morphological description of the larva and pupa). On the 19<sup>th</sup> of November other pupae hatched, resulting in two *C. crowleyi* males. A female *C. crowleyi* hatched on 21<sup>st</sup> November, while one female *C. miranda* emerged on 22<sup>nd</sup> November 2006. After this initial experience of rearing the two species, they were gradually found in different areas in Ghana, from the Volta Region to the well researched Kakum Forest in the Central Region.

In September 2007, a visit to a parkland area near Kakum Forest resulted in the finding and rearing of the third *Cerautola* species in Ghana. Just below a *Crematogaster* ant nest, several *C. miranda*-like larvae were found resting. They were slightly smaller than a fully grown *C. miranda* larva (see description below) and only differed by being slightly darker and lacking lateral red spots (Fig. 9). The feeding behavior of these larvae also differed: while the larvae of *C. crowleyi* and *C. miranda* were always observed feeding solitarily, these larvae remained clustered, grazing the bark like a flock of sheep. This behavior was confirmed to be characteristic of *C. ceraunia* with similar observations made in another locality, where one even larger cluster of 50-80 larvae was found feeding on a tree-trunk (Fig. 11). This habit (and even the look of the larvae) resembled to that of well-known social behavior of the European Processionary Moth *Thaumetopoea processionea* Linnaeus. The other few examples known of Lycaenidae caterpillars developing gregariously are the Asian *Poritia erycinoides* Felder & Felder which also has hairy larvae and not being myrmecophilous (Fiedler 1991) and *Poritia sumatrae* Felder & Felder (Fiedler verb. comm.). The South African *Deloneura millari* Trimen, which also belongs to the Epitolini, and its hairy larvae were found congregating along *Crematogaster* ant trails (Pennington 1940), although this behavior was not repeated in Pringle (2002). *Durbania amakosa* Trimen was said to live gregariously on grasses and to pupate in clusters (Trimen & Bowker 1887), although Clark & Dickson (1971) write that females lay singly or in small batches, while gregarious behavior was not mentioned. Before pupation the larvae of *C. ceraunia* dispersed and pupated solitarily on the vegetation just around the ant-tree, but usually not on the tree bark. Several pupae were found on grass, dry twigs and palm leaves in a five meters circle around the tree trunk. Pupae of *C. ceraunia* were found under very similar conditions in different locations after the first observation. Pupation away from the tree can be easily explained: while the larvae might be protected by pheromone mimic or physically by thick hair cover, the pupae are neither able to produce secretion nor covered by acute setae. They have even been seen attacked by ant workers from the same nest that protected them while they were larvae.

The duration of pupal stage was ten days, exactly the same as for the other two species and as recorded for the closely related *Teratoneura isabellae* Dudgeon by Farquharson (1921).

### The nature of the myrmecophilous relationship

In the detailed analysis of the relationship between Lycaenidae and ants, Fiedler (1991) lists *C. (Epitola) miranda* as myrmecoxenous and *C. (Epitola) ceraunia* as steadily

myrmecophilous (based on observations by Farquharson (1921) and Ackery & Rajan (unpublished)). Pierce *et al.* (2002) classified the Lipteninae (including Epitolini) as not being ant-associated, in contrast to their categories obligately ant-associated and facultatively ant-associated. Typical examples of the obligate category are the African genus *Lepidochrysops* Hedicke (Williams 2008) and the Palaearctic *Maculinea* van Eecke, in which the larvae parasitize ant nests and are unable to survive without their ant hosts, as they are either fed by ant workers or are feeding on ant larvae or pupae (Fiedler 1998, Thomas 1995). In the facultative category, the relationship is looser: a given species is normally ant-associated, but the presence of ants is not essential for survival. In this case the relationship could be either mutualistic or commensal. The larvae of almost all species are known to produce secretions for the ants from special glands.

Observations on the Epitolini indicate that in nature, they might always be associated with *Crematogaster* ants. The females seem only to lay eggs in the ant runs near the nests. Yet, as the present study shows, the larvae develop well without ants in the final instar. From the egg-laying behavior of the female *Cerautola*, it is quite obvious that adults can sense ant pheromones. The females position the eggs close to the nest, regardless of its height on the tree bark. The males usually display around ant trees and they rest on dry twigs or palm leaves close to ant nests. The larvae also sense ants since they rest closely (alongside or below) the nests, normally within 0.5 m. The larvae are frequently visited by single ant workers, which normally approach the resting larvae but turn back immediately after reaching the longest setae. During feeding, the larvae actively move up and down on the bark, seeking fresh lichen: normally one *Cerautola* larva interacts with thousands of ants without any trace of hostile reaction from the ants. The crossing an ant trail by about 50 larvae of *C. ceraunia* caused no aggressive movements from the *Crematogaster* ants. No release of secretion was observed from the larvae and no attacking or milking behavior from the ants was ever observed. Acoustic communication between larvae and ants might also be possible, but measuring the sound and identification of the sound producing organs would require special equipment (Barbero 2008). Also, the ability to produce sound seems not to be directly associated with myrmecophily in European groups of Theclinae, Lycaeninae and Polyommatainae (Schurian & Fiedler 1991, Munguira *et al.* 2008). Possibly the only defense of the larvae against the *Crematogaster* ants is physical through their thick hair cover which is present from the first instar. On the other hand, it is also a fact that no aggressive reaction was ever seen against the larvae, though many other insects were attacked by the same *Crematogaster* ants around the trees which hosted the *Cerautola* larvae. While no advantage of this myrmecophilous relationship has been inferred for the ant host, the definite advantage for the butterflies is the defense against other predators and parasitoids, which avoid interaction with the *Crematogaster* ants, although in few cases other ant species were observed preying on *Cerautola* larvae, and in two cases larvae were found infested by parasitoid flies. Summarizing the observations on the relationship between the *Crematogaster* ants and the *Cerautola* larvae, it comes closest to the neutral



Fig. 9-13. *Cerautola ceraunia*, larvae, pupa, male and female. Bobiri, Ghana.

facultative myrmecophily without parasitizing the ant nest, where the *Cerautola* larvae find shelter around the nest against predators and parasites, while the ants do not recognize the caterpillars as prey or as hostile organisms and therefore they largely ignore them. This does not fit well into the categories of Pierce *et al.* (2002), while according to the classification given by Fiedler (1991), the degree of myrmecophily for all three discussed *Cerautola* species could be: “steadily myrmecophilous (almost all older larvae are nearly permanently attended by ants)”. The myrmecophilous relationship can be stricter in other *Epitolini*, where larvae have been seen entering ant nests (Sáfián personal observation) but this never happened for the three *Cerautola* species discussed.

#### Description of early stages

The 1<sup>st</sup> instar larva of *C. crowleyi* is about 2 mm in size. The fully grown larva measures 26-29 mm, strongly flattened and covered with thick hair, though some of the setae are clustered, confined to the mammillae mainly on the ventral side and around spiracles. The ground-color is light creamy pinkish-grey, with a fine black linear pattern. The black color is very intensive on the segments A1 and A6, appearing as spots chequered with lighter small dots (can be completely black in L2-L3). The lateral side of the larva is bordered with a line of blue spots on segments T3, A1-A6 also with a dark red spot in stages L2-L3 which fades or disappears in L4 (Fig. 2). The prothoracic shield is bright pink, divided on the top by a black-blue double-line,

best visible on the fully developed larva. The head is small, completely black, hidden under the neck-shield. The setae are grey and black, slim and spiky, easily dislodge, longer around the spiracles. The pupa is very well camouflaged, resembling a piece of lichen-covered bark or the excrement of a bird (Fig. 3-4). The structure is similar to the pupa of *Cerautola hewitsoni* Mabille as illustrated in Farquharson (1921). It is attached only at the abdomen and is erect freely on the bark. The surface is gently spiky with short sparse setae, light green in color with olive green and black pattern on the back and with a pair of twin bumps. The ventral side of the abdomen and the wings are darker, with a prominent white patch, which covers partly the legs, the antennae and the wings. There is a black lateral line on the abdomen.

The larva of *C. miranda* is structurally identical to that of *C. crowleyi*, but slightly smaller (the length is 25-27 mm when fully grown); the dark pattern on the dorsal side is stronger, with a strongly visible center-line on the back having parallel side-lines. The prothoracic shield lacks the pink color of *C. crowleyi* and the border spots are dark bluish-grayish-black, with a pale reddish court (Fig. 7). The head and the spiracles are black. Although the ground-color is effectively similar to that of *C. crowleyi*, seeing both together one might get the impression that the larva of *C. miranda* is visibly darker. The pupae of *C. miranda* differ more from those of *C. crowleyi* than the larvae do. The pupa of *C. miranda* lacks the twin bumps on the back, and is darker with more even grayish-green color with black dots on the abdomen, while the wings are patterned with

a different tone of gray (Fig. 8). There are quite a few reddish setae on the thorax and the dorsal side of the abdomen. Larvae of *C. ceraunia* are nearly identical to those of *C. miranda* in both size and pattern (Fig. 9). The former species lacks the reddish spots on the lateral side and the overall look of the larva is slightly darker brown. The pupa is also close to that of *C. miranda*, but paler and the ground color is more creamy beige with red mamillae (Fig. 10). Farquharson (1921) also provides a line drawing of the dorsal view of the pupa. The moulted skin of the larva remains at the base of the pupa of all three species; the hairs of the larva forming an apparently “defensive” circle around the cremaster. The pupal case becomes transparent 10–12 hours before hatching, making the body and the color of the forewings visible. The freshly hatched imagoes are illustrated on Figs 5, 6, 12, and 13.

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